



# Green and Sustainable Remediation 101

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# Agenda

- **Introduction to GSR**
- **Implementing GSR**
- **Industry Perspectives**
- **Project Examples**
- **References**



# Introduction to GSR



## ● Green vs. Sustainable Remediation

- **Green:** *Practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup (EPA, 2010)*
- **Sustainable:** *An integrated assessment of the environmental, economic, and social impacts of remedial activities (ITRC, 2011)*



# Introduction to GSR



## ● Green Remediation

- Maximize benefits and minimize the unintended impacts of common investigation and remediation activities
- Energy: total energy use, efficiency, renewable energy use
- Air emissions: greenhouse gas emissions, other air pollutants
- Water: use/reuse, impacts to water resources
- Land impacts: land management and reuse, ecosystems protection
- Waste: reduction, recycling, and management



EPA, 2008

# Introduction to GSR



## ● Sustainable Remediation

- Involves the integration of resource conservation, economic viability, and community safety and acceptance into the remedy
- Considers social and economic issues in the planning and selection of cleanup approaches, looking beyond site-specific risks to consider external impacts
- Best practical use of a site, not always unrestricted use



# Introduction to GSR



## ● Commonly Heard Opposition Views

### ■ GSR is more \$\$\$\$

- Not true, typically the “greener” approach is the least expensive and is something that is performed anyway
  - Direct-Push
  - Field Screening
  - Reduce transportation
- Different way of evaluating the benefit

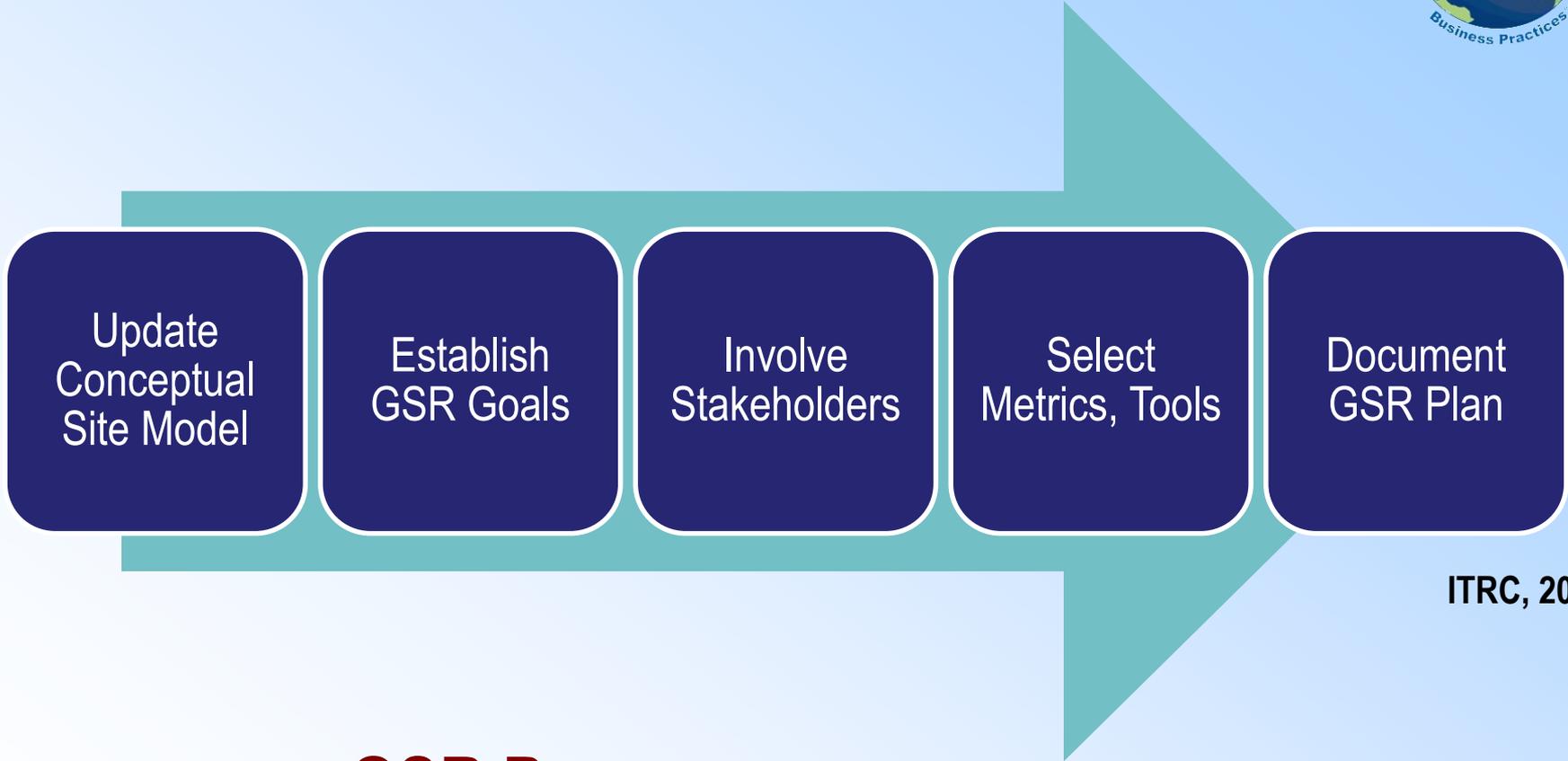
### ■ GSR takes too much time

- Yes and No – Basic evaluations can be done quickly while higher level evaluations can be time consuming
- Decide what is appropriate within budgeted timeframe

### ■ GSR is a fad and will go away soon enough

- Emerging, has not hit its peak yet
- Getting more momentum on federal and state levels
  - EPA Requiring GSR Considerations in RFPs/Projects
  - States developed and implementing GSR practices and BMPs

# Implementing GSR



ITRC, 2011

## GSR Process

# Implementing GSR



- **Update Conceptual Site Model (CSM)**
  - **Identify activities that are relevant to GSR**
  - **Identify/Evaluate:**
    - Community features/uses near site
    - Ecological assets/sensitive areas
    - Potential for on-site renewable energy use
    - On-site reuse of groundwater
    - On-site waste treatment
    - Proximity of disposal/recycling facilities
    - Stage of the project in the cleanup process
      - Can be implemented at any phase, FS most often

# Implementing GSR



## ● Establish GSR Goals

### ■ Consider:

- Project setting, surrounding, circumstances
- GSR components
- EPA Core Elements (previous slide)
- Project drivers (regulatory, social, future use, etc.)
- Note: goals can be non-remediation based

### ■ Example Goals

- Reduce greenhouse gas emissions
- Conserve energy/natural resources
- Generate local economy boost
- Provide added community benefit

# Implementing GSR



## ● **Involve Stakeholders**

### ■ **Identify key stakeholders**

- May or may not be subset of overall project stakeholders
- May be new stakeholders not currently part of team
- Outside of the box thinking
- Examples: owner/operator, developer, regulatory agencies, lender, local community associations, political representatives, etc.

### ■ **Engage stakeholders**

- Engage at appropriate point, earlier the better!
- Continue to keep them updated
- May require more frequent updates that regulators

# Implementing GSR



- **Involve Stakeholders**
  - **Different stakeholders have different values**

Stakeholders	Values	GSR Metrics
Project leader	Project efficiency	Energy, cost savings
Property owner	Property value	Land use
Community group	Safety and quality of life	Traffic volume, noise
Site regulator	Health and environment	Air pollutant emissions, ecological habitat

SURF, 2013

# Implementing GSR



## ● Select Metrics

- Metrics – measurement of goal achievement
- Establish metric for each GSR goal
- Can be quantitative or qualitative
  - Quantitative – measured/calculated
  - Qualitative – subjective
- Select evaluation level
- Table 4-1 of GSR-1 (ITRC 2011 Guidance)

# Implementing GSR



- **Select Metrics**

- **Example Metrics (from Table 4-1 of GSR Guidance)**

	Land	Water	Waste	Community	Economic		
Metric						Metric Units	Metric Description
Fresh Water Consumption						gallons	volume of fresh water used
Biodiversity						species count	assessment of impacts on biodiversity
Renewable Energy Use						gallons; BTU; kWh	measure of use of renewable energy
Greenhouse Gas Emissions						CO <sub>2</sub> equivalents emitted	tons of GHGs emitted
Material Use						Kg	kg of total material use, or mass by category of material
Employment						jobs created	number of jobs created as a result of implementing remedy
Capital Costs						\$	capital costs of project
Community Impacts						subjective	impacts of project on the community
Cultural Resources						subjective	impacts of project on cultural resources

# Implementing GSR



## ● Select Tools

- Tools – Developed to track metrics easier
- No standard methodology/tool
- When choosing which tool to use, consider:
  - Goals/metrics
  - Scope and budget
  - Available data
  - Regulatory program
  - Level of detail
  - Technologies being evaluated

# Implementing GSR



## ● Select Tools

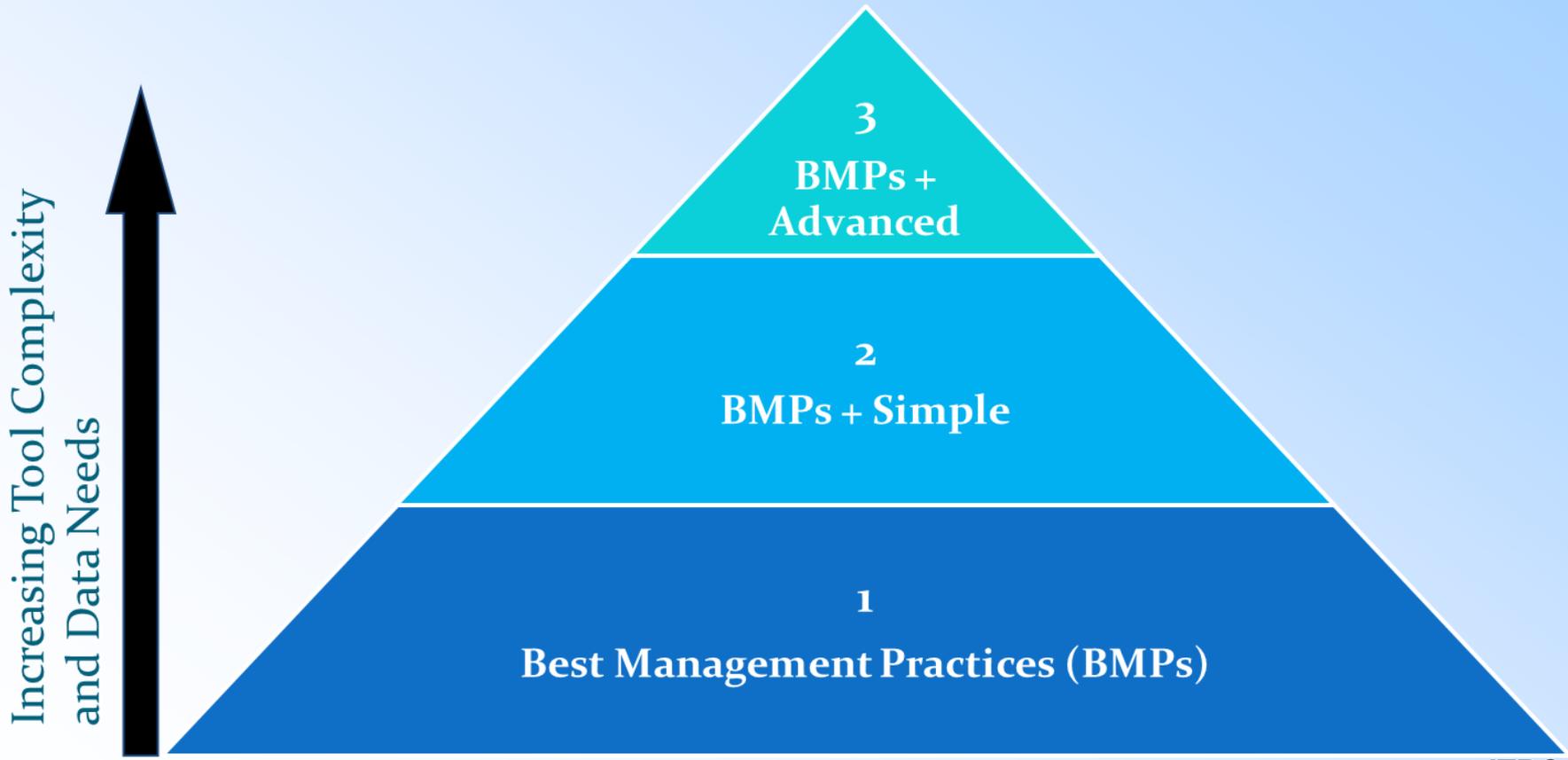
### ■ Determine Level of Detail Required

- Best Management Practices (BMPs)
  - Adopt common sense practices
  - Does not include quantifying net impacts
  - Most common and also easiest
- Simple
  - Qualitative or semi-quantitative evaluation
  - Basic calculators/spreadsheets
  - Ranking/scoring
- Advanced
  - Complex quantitative evaluation
  - May include life-cycle analysis/footprint analysis
  - Time consuming and \$\$\$\$

# Implementing GSR



- **Select Tools**



ITRC, 2011



# Implementing GSR



- **Tools**

- **Basic Evaluation**

Metric	In Situ Thermal	Bioremediation	In Situ Chemical Oxidation
Greenhouse gases	☹️	😊	😐
Solid waste	😊	😊	😊
Sensitive species	😐	😊	😐
Community disturbance	😊	😊	😊
Community acceptance	😊	😐	😐
Cost	☹️	😊	😐

# Implementing GSR



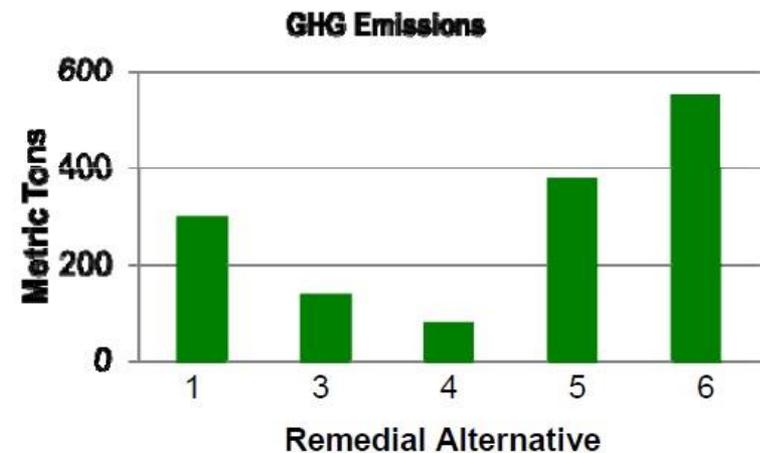
- **Tools**

- **Sitewise™ – USACE/Navy**

Remedial Alternative	Energy (MMBTU)	Emissions (Metric Tons)			Accident Risk Injury
		GHGs	NO <sub>x</sub>	SO <sub>x</sub>	
Alternative 1	3.05	300	0	0	0
Alternative 3	3.05	140	0	0	0
Alternative 4	3.05	80	0	0	0
Alternative 5	0.22	380	6.0E-05	1.0E-06	3.14E-06
Alternative 6	0.22	550	6.0E-05	1.0E-06	3.14E-06

Comparative graph generated for each metric

<http://www.ert2.org/t2gsrportal/SiteWise.aspx>



Output Screen

# Implementing GSR



- **Tools**

- **EPA Footprint Analysis**
- **Life Cycle Analysis – SimaPro**
- **Basic Evaluation – excel, etc.**
- **ISI Envision (EA developing internal tools)**
- **Other (private entity, company-developed)**

# Implementing GSR



- **Document GSR Plan**

- Document the entire GSR process
- List the assumptions used
- Provide results (checklists/spreadsheets/etc.)
- Include how the results will be used
- Can either be section within a document or stand-alone report

# Industry Perspectives



## ● User Perspective

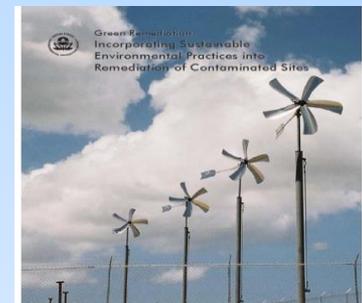
- DOD (USAF, Navy, USACE, DOE)
- Showing up on RFPs (likely to increase with advancement of knowledge)
- Corporations (Boeing, Ford, Pfizer, Shell, Exxon, Dupont)
- Growing interest in smaller markets

## ● Regulatory Perspective

- Executive Order (EO) 13423: Strengthening Federal Environmental, Energy, and Transportation Management
- EO 13514: Federal Leadership in Environmental, Energy, and Economic Performance
- EPA – greater push for GSR considerations
- States (NY, CA, MN, OR, etc.) – Established guidance



ENGINEERING SERVICE CENTER  
DEPARTMENT OF THE NAVY  
GUIDANCE ON GREEN AND SUSTAINABLE REMEDIATION



DER-31 / Green Remediation	
New York State Department of Environmental Conservation	
DEC Program Policy	
Issuing Authority: Val Washington	Title: Deputy Commissioner Office of Remediation and Materials Management
Date Issued: August 11, 2010	Latest Date Revised: January 20, 2011

# Industry Perspectives



- **Consultants**

- Many larger consultants have active programs
- Mostly large business with DOD clients
- Growing with small businesses

- **EA Perspective**

- PBC
- EA Sustainers

# Project Examples



## ● Former Quarry Site

- Water recycling
- Performed GSR evaluation for emissions/water/fuel → \$\$\$

	Non-Recycled	Recycled		
<b>Water Requirements</b>				
Daily Water Requirement (gal)	200,000	200,000	Diesel Pump Operation (Frac Tank-TTU)	
# of Days/Month Required	30	30	GPM (operating rate) <sup>1</sup>	1000
# of Months of Operation	3	3	Total minutes	9072
Total Water Requirement (gal)	18,000,000	18,000,000	Total hours	151
Recycled Water Used	0	9,072,000	Fuel consumption rate (gph) <sup>3</sup>	4
Total Water Imported	18,000,000	9,928,000	Total fuel consumed (gal)	605
			CO <sub>2</sub> emissions (lbs)	19427
<b>Transportation</b>				
Distance Source/Site (mi, roundtrip)	40	40	Pump Operation (Treatment Plant Discharge-Frac Tank)	
Gallons per trip	6,000	6,000	Pump Power Usage (kwarts, assume 0.5 HP) <sup>4</sup>	1000
# trips	3,000	1,488	Total hours (hr, assume 24/7/3 months)	2160
Total miles	120,000	59,520	Electricity requirement (MWh)	2.16
Fleet Transporter fuel economy (mpg) <sup>5</sup>	6	6	Emissions rate (lbs/MWh) <sup>5</sup>	1269
Total fuel consumed (gal)	20,000	9,920	CO <sub>2</sub> emissions (lbs)	2741
CO <sub>2</sub> Emissions (lbs)	444,000	220,224		
<b>Recycled Water Availability</b>				
Treatment Plant Discharge (avg. gpm)	70		Emissions Associated with Equipment Usage	
Daily Discharge (gal)	100,800		Excavator operation (hours)	10
# of Days Required	90		fuel consumption (gph)	10
Total Water Available (gal)	9,072,000		Total fuel consumption (gal)	100
			CO <sub>2</sub> emissions (lbs)	2220
<b>CO<sub>2</sub> emissions rates</b>				
Diesel (lb/gal) <sup>2</sup>	22			
<b>Summary</b>				
	Non-Recycled	Recycled		
Total Emissions (lbs CO <sub>2</sub> )	444,000	230,612		
Total Fuel consumed (gal)	20,000	10,925		
			Associated Cost Savings <sup>6,7,8</sup>	
Net CO <sub>2</sub> Emissions Reduction (lbs)	205,388		\$932	
Net Imported Water Reduction (gal)	9,072,000		\$381,024	
Net Fuel Reduction (gal)	9,375		\$28,126	
			<b>Total Cost Savings</b>	<b>\$410,081</b>

**Sources**

- 1 - Argonne, GREET Fleet Footprint Calculator 1.1a, 2010
- 2 - EPA, Average Carbon Dioxide Emissions Resulting from Coal and Diesel Fuel, 2007
- 3 - Godwin Pumps, Model CD150M (assuming operating rate of 1000 GPM)
- 4 - Average rate based on review of pump manufacturer specification data
- 5 - Delmarva Power
- 6 - Carbonfund.org - \$16/metric ton
- 7 - Based on water provider costs of ~ \$0.042/gal
- 8 - Based on average diesel rate of \$3.00/gal during remedial action

## RESULTS

	Carbon Dioxide Emissions (lbs)	Total Imported Water (gals)	Total Fuel Consumed (gal)
Offsite Water	444,000	18,000,000	20,000
Onsite Recycled Water	238,612	8,928,000	10,625
Net Reduction by Recycling Water	205,388	9,072,000	9,375
Associated Savings with Water Recycling	\$932	\$381,024	\$28,126



# Project Examples

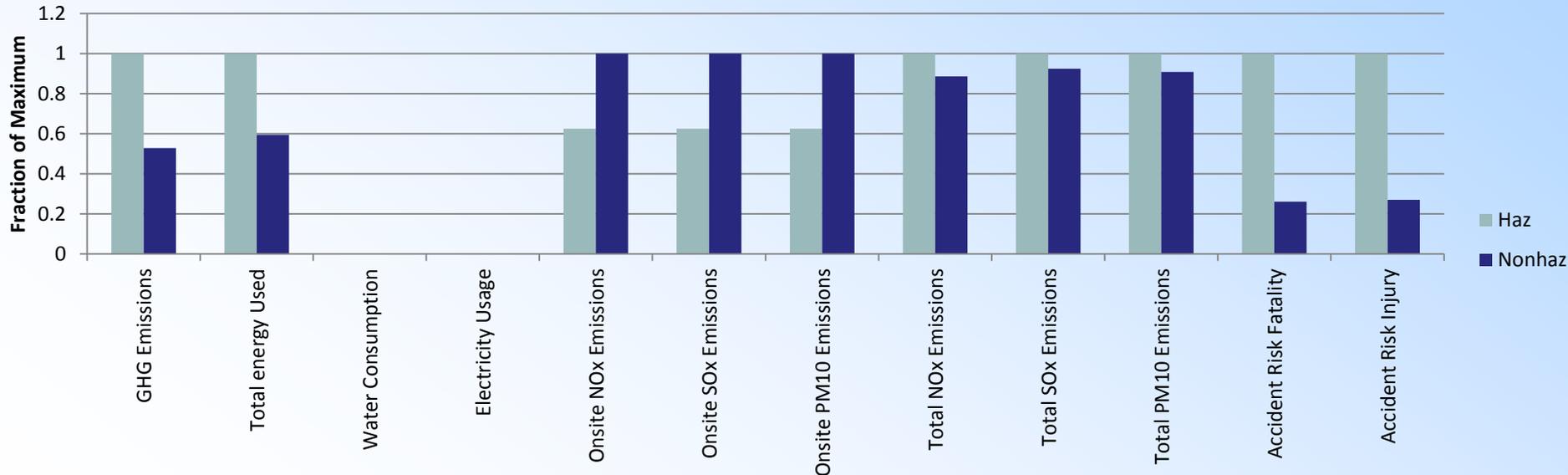


Process	Greenhouse Gas Emissions (metric tons)	Total Energy Used (MMBTU)	Cost (\$)
Stabilization / Nonhazardous Disposal	990	17,500	3,537,500
Hazardous Disposal	1,876	29,400	8,525,000

## Shooting Range Remediation

- 89 % Reduction in Greenhouse Gases
- 68 % Reduction in Energy Usage
- 140 % Reduction in Cost

### Normalized Impacts





# References

- **ITRC**

- <http://www.itrcweb.org/Team/Public?teamID=7>

- **EPA**

- **HQ:** <http://www.epa.gov/reg3hwmd/bf-lr/sustainablereuse.htm>
- **CLU-IN:** <http://clu-in.org/greenremediation/index.cfm>
- **R2:** [http://www.epa.gov/region2/superfund/green\\_remediation/](http://www.epa.gov/region2/superfund/green_remediation/)
- **R5:** <http://www.epa.gov/Region5/waste/cars/remediation/index.html>
- **R9:** <http://www.epa.gov/region9/climatechange/green-sites.html>
- **R4:** <http://www.epa.gov/region4/superfund/allresource/greenr/greenr.html>

- **ASTM**

- **E2893 – Greener Cleanups:** <http://www.astm.org/Standards/E2893.htm>
- **E2876 – Integrating GSR:** <http://www.astm.org/Standards/E2876.htm>

# References



- **SURF**

- **White Paper:** <http://www.sustainableremediation.org/library/issue-papers/SURF%20White%20Paper.pdf>
- **Resources:** <http://www.sustainableremediation.org/remediation-resources/>

- **Navy**

- [https://www.navfac.navy.mil/navfac\\_worldwide/specialty\\_centers/exwc/products\\_and\\_services/ev/erb/gsr.html](https://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/erb/gsr.html)

- **USACE**

- <http://www.erdc.usace.army.mil/Media/FactSheets/FactSheetArticleView/tabid/9254/Article/476729/center-for-the-advancement-of-sustainability-innovations.aspx>

# References



## ● States

- **NYSDEC:** [http://www.dec.ny.gov/docs/remediation\\_hudson\\_pdf/der31.pdf](http://www.dec.ny.gov/docs/remediation_hudson_pdf/der31.pdf)
- **CA DTSC:** [https://www.dtsc.ca.gov/OMF/Grn\\_Remediation.cfm](https://www.dtsc.ca.gov/OMF/Grn_Remediation.cfm)
- **IL EPA:** <http://www.epa.illinois.gov/topics/cleanup-programs/greener-cleanups/index>
- **WI DNR:** <http://dnr.wi.gov/topic/Brownfields/WISRR.html>
- **MA DEP:** <http://www.mass.gov/eea/docs/dep/cleanup/laws/14-150.pdf>
- **MN PCA:** <http://www.pca.state.mn.us/index.php/topics/preventing-waste-and-pollution/sustainability/index.html>
- **CT DEEP:** <http://www.ct.gov/deep/greenremediation>
- **OR DEQ:** <http://www.deq.state.or.us/lq/cu/greenremediation.htm>
- **MA DEP:**  
<http://www.mass.gov/eea/agencies/massdep/cleanup/regulations/sustainable-remediation-faqs.html>